THE RAPIDEYE MISSION DESIGN

Dr. George Tyc, John Tulip, Daniel Schulten

MacDonald Dettwiler and Associates
13800 Commerce Parkway, Richmond B.C., V6V 2J3, Canada
Phone: +1 604 278 3411, Fax: +1 604 231 2127, dschulte@mda.ca

Dr. Manfred Krischke, Michael Oxfort

RapidEye AG
Wolfratshauser Strasse 48, 81379, München, Germany
Phone: +49 89 72 495497, Fax: +49 89 72 495232, krischke@rapideye.de

1. ABSTRACT

The RapidEye mission is a commercial Remote Sensing mission by the German Company RapidEye AG. The RapidEye mission will deliver information products for various customers in the Agricultural insurance market, large producers, international institutions and cartography. The mission that generates these information products consists of a constellation of five identical small satellites and a sophisticated ground infrastructure based on proven systems.

The five satellites will be placed in a single sun-synchronous orbit of approximately 620 kilometers, with the satellites equally spaced over the orbit. The satellites will each carry a 5 band multi-spectral optical imager with a ground sampling distance of 6.5 meters at nadir and a swath width of 80 km. The RapidEye system has the unique ability to image any area on earth once per day and can also provide large area coverage within 5 days. This capability along with the processing throughput of the ground segment allows the system to deliver the information products needed by the customers reliably and in a time frame that meets their specific needs.

The RapidEye system offers a unique remote sensing service where the system solution was designed specifically around customer's needs for particular information products in selected market segments. The ability of the system to monitor large areas within short time intervals and at the same time respond to specific requests within a single day offers a capability that is not available in the present Remote Sensing systems.

2. INTRODUCTION

The RapidEye Mission is a commercial undertaking by the German company *RapidEye AG* who intend to offer a land information service to a variety of customers. These information service products are based on the data that is generated by a constellation of Earth Observation satellites. The information products that RapidEye will be offering are focused on the following four key market segments:

- Agricultural Insurance: RapidEye will offer regularly updated field maps to help insurers in the insurance contract assessment and will support the loss adjustment process by providing quick and reliable information about damaged areas.
- Agricultural Producers (farmers): The information generated by the RapidEye system will support the precision farming system substantially by regularly providing information about the crop conditions.
- International Institutions: International agencies and institutions require to have knowledge of the levels of expected crop harvests, monitor the usage of subsidies and provide

emergency relief in disaster situations. RapidEye will be able to provide up-to-date and comprehensive information for these purposes.

- Cartography: The need for current maps is significant given that most maps are at least 10 years and often over 50 years old. RapidEye will be the first company to provide regular updates at a scale of 1:25,000. Commercial sales to the military will be a major opportunity in this segment.

To meet RapidEye's business needs, the mission design must have the following key characteristics:

- Multi-spectral Optical Imager: High quality ortho-rectified imagery is required in 5 spectral bands that provides a ground sampling distance (GSD) between 5–10 m.
- Global Daily Revisit: Rapid turn-around from a customer's request for information products to delivery is a key requirement for RapidEye's market segments. Hence, it is required that the satellites have daily revisit capability anywhere on the Earth.
- Rapid Area Coverage: To allow monitoring large areas of interest and provide frequent information updates to customers, the system must have the capability to provide large area coverage in less than 6 days in primary regions of interest.
- Large Data Capacity: A significant ortho-image data capacity is required to allow building up and maintaining an extensive database of information for large areas of interest.

3. RAPIDEYE MISSION OVERVIEW

To achieve the key business requirements, RapidEye system consists of five identical small satellites and a ground infrastructure as shown in Figure 1.

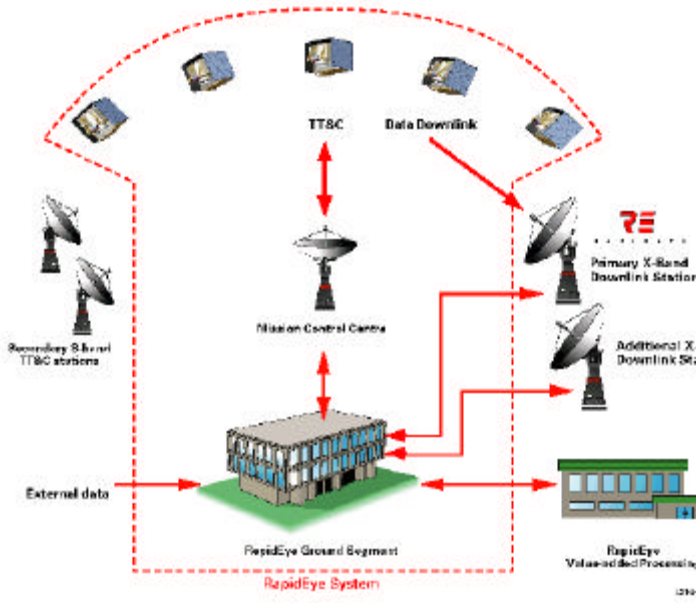

Figure 1 The RapidEye System

The five satellites will be launched together on a single launch vehicle into a sun-synchronous orbit at an altitude of approximately 620km. The satellites will be in a single orbit plane, equally spaced around the orbit. As a result, the satellites follow each other approximately 19 minutes apart. Each satellite, weighing approximately 150 kg, carries a push broom optical imager that provides a swath width on the ground of approximately 80 km. The imager's field-of-view (FOV) can be oriented across track be rolling the spacecraft by up to +/-25 degrees to provide the necessary coverage capability. The RapidEye mission ground infrastructure includes: a dedicated Mission Control Centre to control the spacecraft constellation; a ground segment that provides the data processing, archiving facilities and the customer interface; commercial data downlink sites; and the RapidEye value-added product processing facility that uses the ortho-rectified image data from the ground segment to generate the information products needed by the customers. The key mission parameters are given below in Table 1.

Table 1 - Key Mission Parameters

Parameter	Value	Parameter	Value
Orbit	600-620 km, sun-synch	Detector	12 K pixel linear CCD per band
Number of Satellites	5	Nadir Pixel GSD	6.5 m
Spacecraft Mass	150 kg	Swath Width	80 km
Image Data Downlink	> 60 Mbps (in X-band)	Global Revisit Time	< 1 day
Onboard Data Storage	> 1500 km of image data	Average Coverage Repeat Period (Europe & North America)	< 5 days
Max Spacecraft Roll Angle	25 deg	DEM Generation Capability	Yes
Payload Type	Push broom scanner (no moving parts)	Mission Lifetime	7 years
No. of Optical Bands	5 (400–850 nm)		

To meet the business objectives, the RapidEye mission implementation must be highly cost effective while also providing a high degree of reliability. To achieve the cost and reliability goals of the program, the spacecraft hardware is based to the maximum extent possible on heritage designs. For example, the spacecraft bus design is based on a flight proven microsat platform requiring very little new development. The small spacecraft size allows all 5 spacecraft to be launched on one launch vehicle providing significant cost savings to the program. Also, the identical design for all five spacecraft enable the advantages of scale and efficient assembly and integration. To address the high reliability, two levels have been designed into the mission. First of all the spacecraft has internal redundancy for mission critical components and graceful failure modes (i.e., providing reduced performance in the event of a failure) so that they are at least one failure tolerant. Secondly, all the RapidEye business requirements can be met by a constellation of only four satellites, allowing for the failure of a complete satellite. This comprehensive set of redundancy is considered as one of key requirements for investors in the RapidEye business.

4. GROUND SEGMENT DESCRIPTION

The RapidEye Ground Segment features Commercial-Off-The-Shelf (COTS) hardware that has been selected for its performance, maintainability and expandability. The proposed architecture features high-performance technologies for the network, processors, output peripherals, archive, and workstations, which will be installed at RapidEye's operational facility in Germany. Figure 2 provides a conceptual overview of the Ground Segment.

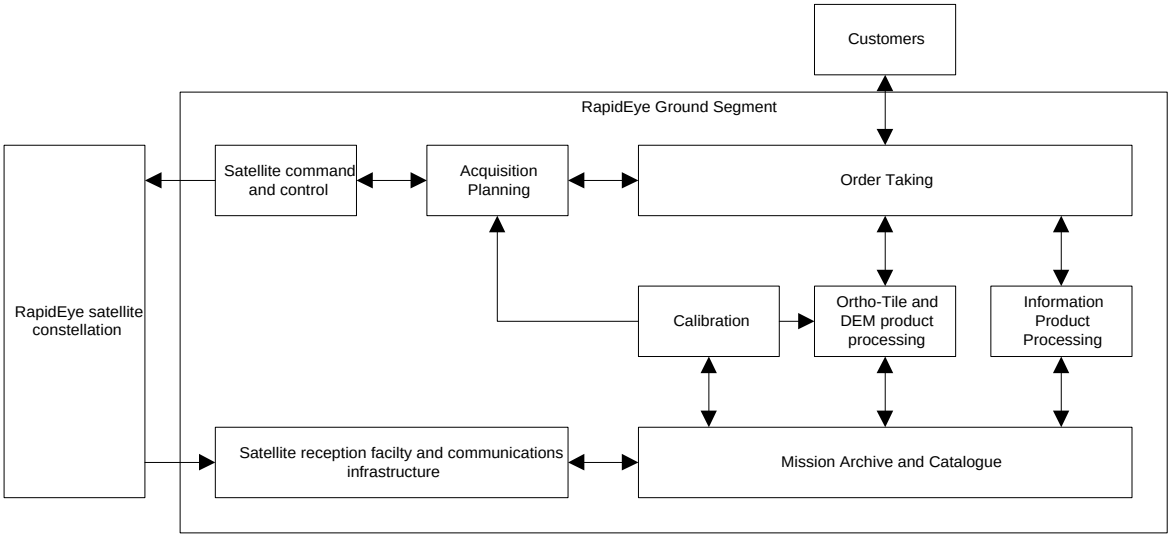

Figure 2 RapidEye Ground Segment

The Ground Segment provides the following key functions:

- A customer order interface capability.
- Satellite acquisition planning function that takes into account satellite constraints, weather and cloud predictions, the underlying data acquisition plan, and special image tasking requests for stereo data acquisitions and acquisition of specific targets.
- Satellite command and control to task the constellation and maintain its health and safety.
- Image processing capablity to convert raw imagery into ortho-products.
- A capability to extract DEMs from stereo imagery using an optimal mix of automated processing and manual editing.
- A calibration capability to ensure the performance of the sensors and processing system.
- An interface to the value added information product processing facility.
- A product catalogue and multi-tiered data archive for raw data, ortho-products, DEMs and information products.
- Support to other data providers to obtain weather forecasts, cloud cover predictions, DEMs and other information

5. CONCLUSIONS

The RapidEye mission is a unique commercial small satellite Earth Observation mission that is focussed entirely on delivering an information service to the RapidEye customers. All system design decisions are based on the business plan requirements and have resulted in a highly cost effective and very capable constellation of five reliable small satellites along with a proven ground infrastructure. The system is capable of delivering the information products needed by the customers reliably and in a time frame that meets their specific needs.

The RapidEye mission will generate a unique earth observation data set on which exclusive information products can be developed. The ability of the system to monitor large areas within short time intervals and at the same time respond to specific requests within a single day offers a capability that is not available in current remote sensing systems.